Published in Proceedings of the 3rd International Conference on System Reliability and Safety (ICSRS) 2018, Barcelona, Spain, 23-25 November 2018, which should be cited to refer to this work.
DOI: 10.1109/ICSRS.2018.8688873

A Critical Incident Drill Based on Service Design to Improve Digitization Acceptance of Processes in Air Traffic Management

An Organizational Test Conducted at skyguide Involving an External IT Provider

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Abstract— The digitalization of business processes implies important changes in the organization of air traffic control companies. In this research, we have developed an original critical incident drill approach based on service design techniques combined with risk management. The aim is to take into account the co-production elements inherent to any complex service system and also the necessary interplay between explicit (information) and tacit (know-how) knowledge. The critical incident drill begins with a preparation where immersion episodes and modeling of new digital processes by the service blueprint allows to imagine coherent and coordinated interactions between human expertise, information system and any external IT provider. Once ready the new process is simulated in real size and conditions. Co-creation between stakeholders makes it possible to conduct a relevant analysis of the risks as well as opportunities for improvement. This approach has been used successfully by skyguide to test and implement new air traffic management digitalized processes.

Keywords-component; Air Traffic Management; Digitalization; Critical Incident Drill; Service Design;

I. INTRODUCTION

A critical incident represents a disruptive event along the realization of a given process or procedure. As a critical incident might impact an entire organization, approaches called CIT (Critical Incident Technique), originally developed by John Flanagan [1], enable to observe human behavior related to a given critical incident. It is thus a psychological method. The original approach is flexible and has evolved in many different ways. In this paper, we have employed it as a CIT drill. Our goal has been to develop a CIT drill by integrating an original approach of service design and risk management in order to find solutions to get back to normal in a minimum time as well as to fix the process or the procedure itself to increase its reliability. The exercise of drill is interesting in the sense that the repetition of a given hypothetical situation allows to acquire an adapted know-how to treat promptly the same situation in real context. It is typically used in sport, music and in the military. The drill can also be used to train and to deal with critical incidents in the context of service processes. In this paper, we will show how the critical incident drill related to new digital processes can gain relevance through service design techniques.

The aim is thus to orchestrate the typical interactions between the digital process and the various actors involved in this operation. This orchestration is done by service blueprinting and then rehearsing it through simulation. A CIT can be seen as a feedforward control. Feedforward control is also known as advanced control or predictive control and is expected to take appropriate measures in advance to prevent problems from occurring. It is indeed quite well known that reacting in an ex-post manner will cost more and will be less efficient (i.e. prevention is better than the cure). In the case of a critical incident, to anticipate its resolution, we must rely on weak signals indicating that a risk is deteriorating and increasing thus that the probability to reach the objective in due time is being reduced. If the level of this risk deterioration becomes too critical, an alert will arise. Based on this alert, the manager will appraise the situation and depending on its criticality, she/he might implement mitigation strategies as a preventive way. The difficulty when anticipating business objective achievement is that indicators are usually of qualitative nature and related to human factors (i.e. attitudes and behaviors). In measurement systems, one aspect not yet considered is typically the influence of employees on successful service performance.

We have experimented this approach at skyguide in the beginning of year 2018. A preparation of the drill, in January and February, has enabled us to adapt the WHO simulation exercise standard [2] for the purpose of the CIT drill. Skyguide and HES-SO Valais-Wallis have worked together on field data collection (immersions and semi-directed interviews), on the development of service blueprints and scenarios of critical incidents as well as all the planning of resources and schedule to conduct the exercise during two two-day workshops. We first explained how we can model through service blueprinting the interaction between providers and clients that typically happens during a service experience. Finally, based on the blueprint and the contribution of both explicit and tacit knowledge, the new digitalized service process has been staged and rehearsed before it goes into production through its implementation.

Skyguide provides air navigation services in Switzerland and in the adjacent airspace of neighboring countries. It has 1500 employees at 14 locations throughout Switzerland. Each year, it guides 1.2 million civil and military flights safely and efficiently through Europe's most complex airspace. It provides innovative solutions that meet customer needs and thus contribute to maintaining the attractiveness of the Swiss business location. In 2017, skyguide received the Single European Sky Award for its leading role in introducing Service-Oriented

Architecture in air traffic management. At the core of this transformation are system modelling, an agile delivery methodology and close collaboration with partners.

The purpose of the drill exercise was to evaluate the preparedness, readiness and response mechanisms of skyguide's technical operations and support units to resolve incidents related to the new IT infrastructure service delivery model, and to provide opportunities to validate existing mechanisms and to identify areas for enhancement.

The paper is organized as follows. In Section 2, we present a brief literature review about the notion of explicit and tacit knowledge in service production. In section 3, we present the model of critical incident technique drill that we have developed. It is grounded on two important tools of service design that are service blueprint and theater re-enactement. In Section 4, we present the critical incident drill workshops that took place at skyguide. In section 5, we provide a discussion as well as a conclusion.

II. LITERATURE REVIEW

Service design represents a rigorous and systematic process that goes from a service concept to its realization. A service production has the particularity that clients are as well co-producers and that the raw material of service is considered to be knowledge. In this section, we explain based on the scientific literature, how explicit and tacit knowledge are crucial to understand the digitization of service processes.
According to Nonaka [3], two kinds of knowledge can be conceptually distinguished along a continuum: Tacit knowledge, which is non-verbalizable, intuitive, and unarticulated, involves nuanced comprehension, relies upon knowhow and wisdom accumulated from collaborative experience, and is thus difficult to formalize and communicate [3], [4],[5]; and Explicit knowledge, which is predominantly codified.

More specifically, tacit knowledge is the source of ideas [6]. If a new idea is based only on reconfigured existing explicit knowledge, then it will engender only incremental innovations [7]. By contrast, ideas based on tacit knowledge are likely to prompt radical innovations or novel solutions [7],[3]. When new schemes are created, they take hold first as tacit instincts and intuitions based on experience before explicit concepts and solutions can be developed. Although such tacit knowledge is difficult to apprehend, it is essential to the innovation process [8]. In today's digitalized world in which competitors and customers have easy, immediate access to explicit knowledge, tacit knowledge has become more and more valuable to firms that can develop it as a dynamic capability [9]. Organizations can gain a competitive advantage by identifying, formalizing, codifying, acquiring, preserving, and transferring tacit knowledge so that it becomes a critical resource. Accordingly, service companies have to build competitive advantage by building specific expertise and skills to become knowledge-based organizations and even tacit knowledge-based ones. A knowledge-based service refers to a service delivered by highly trained providers that offer high-quality services designed to meet customers' needs [10]. In knowledge-based services, intellectual capital embedded in people and systems is critical. That evolution implies a different organizational model that relies more on creativity and implicit knowledge, which is the essence of expertise. In the digitalization of work, unfortunately solely the explicit knowledge dimension is taken into account. In fact, both explicit and tacit knowledge will play a crucial role in the digitalized services of tomorrow. They must then be orchestrated in a precise manner. Pursuing with the analogy with music, the musical score we are using for this purpose is called a service blueprint and has been developed by Shostack [11].

III. SERVICE BLUEPRINT AND THEATER RE-ENACTMENT

The new digitalized operating modes must thus be orchestrated into a consistent service experience. The service blueprinting model enables the researcher to visualize the salient attributes (i.e. main elements of perceived value) of the designed service. In a general manner, the service blueprinting [12] corresponds to a simplistic representation of a service experience. The blueprint is often realized under the form of a matrix defined by two axes (see Figure 1).

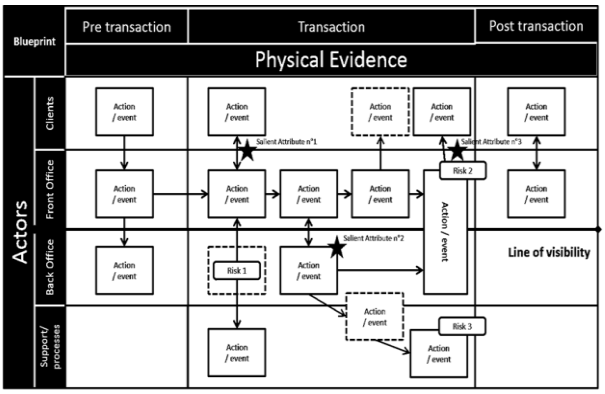

Figure 1. Service blueprint structure (adapted from [12], S. Barbieri, [13])

The horizontal axis includes the various stages of the service, while the various actors are identified on the vertical axis. The horizontal axis is divided into three parts, namely: 1) the "pre-transaction," which is the phase that precedes the contact with the customer; 2) the "transaction," which corresponds to the service per se, and finally; 3) the "post-transaction." The vertical axis stages all the actors involved in the service experience, such as the "customer," the "front office," the "back office," as well as the supporting functions (e.g., the suppliers). The customer is the beneficiary of the service, whereas the front office represents the part of the service provider system who is directly in contact (visible) with the customer. The back office concerns the employees who are usually hidden from the customer behind the service offer, and who support the front office. All the actions and/or the activities associated with every involved actor are displayed, according to the various stages of the service in question. Finally, the progress of the service experience is divided by a "line of visibility," which distinguishes the visible and non-visible parts of the service from the point of view of the customer, namely the front and the back office. Critical Incident Technique is in our case modeled in a scenario that is "drawn" on a service blueprint. CIT has been already used in conjunction with a service blueprint in [14].

IV. A CIT DRILL MODEL BASED ON SERVICE DESIGN

Role playing and theatrical techniques based on a blueprint are then employed to view the resolution of the problem offered by the new service. In this step, the organization learned to stage the given service experience. A stage director accompanies the participants through concrete role playing and theatrical approaches to put into life the new service modelled through a service blueprint. Experts and managers of the organization (with different backgrounds) take an active part in this step of the process to ensure the business relevancy of the newly created digital service process. By systematic and rigorous rehearsal and theatre re-enactment, management, observers and participants taking part to the experiment discover ways of doing (or operating modes) that will allow effective problem solving and generate perceived value for the customer (here in a B2B relationship). The setting is particularly effective at generating innovations allowing the organization to exploit untapped salient attributes of innovative services while insuring economic growth and development. The potential for service improvement through the staging is enormous. Indeed, it provides the workforce with service testing skills that are often lacking in the profession. All experiments are conducted in a Service Design Laboratory, which represents a large office-equipped space that allows performing service experiments of all kinds.

After this staging step comes the real implementation of the service, its scaling-up, its quality management, its monitoring and its pricing. The objective of this last step is to learn how to make the new service fully functional by applying in a precise manner the previous staging and script-based theatrical steps. This last step is thus devoted to solving technical problems related to implementation. The overall process is shown in Figure 2. In the pre-exercise, immersions episodes, semi-directed interviews, walk-through, work on documentations and focus groups enable us to develop a series of blueprints corresponding each time to a given scenario of a new digitalized process involving a critical incident. Then in the exercise conduct phase, based on a staging that mimics real conditions, a first play of the blueprint is conducted. Actors are professionals that will be in charge of running the new processes. Observers will not be directly in charge of the new process. However, they are stakeholders of it. After the play based on templates (we are here using ones that are adapted from the WHO simulation exercises manual [2]). The goal is that based on the collected information, each observer asks a question related to a risk that might be related to the critical incident under study. Through a structured brainstorming that is fully documented and filmed, a full risk assessment is realized. At the end of the session, the stage director choses a single risk. Then the actors have some time to imagine a response to the chosen risk.

The actors play again the same blueprint. However, at this step they add the response that they have conceived by themselves. After that, an assessment is conducted but this time to evaluate the potential of the proposed response and other alternative are discussed. Once the drill is over the service blueprint is adapted to take into account the best response and finally it is validated and implemented (put in production).

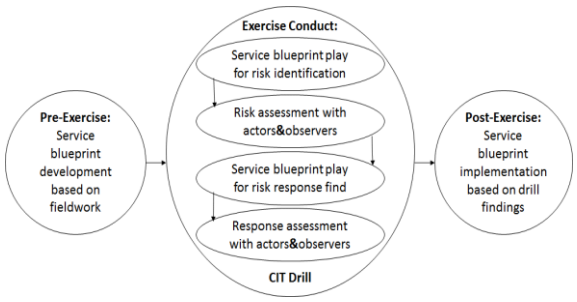

Figure 2. A Critical Incident Technique Drill based on Service Design

V. EXPERIMENT AT SKYGUIDE

The purpose of the simulation exercise we have conducted beginning of year 2018 was to evaluate the preparedness, readiness and response mechanisms of skyguide's technical operations and support units to resolve incidents related to the new IT infrastructure, and to provide opportunities to validate existing mechanisms and to identify areas for enhancement.

The simulation exercise realized correspond to a "drill" simulating multiple cases of technical incidents. Through the exercise, participants (more than 50) had to test the procedures involved in responding to given incidents, from the symptoms of an incident up until the formal resolution of the incident.
The Scenario Narrative documents describe the "story line" for all incident scenarios to be simulated during the exercise. Starting from the symptoms of an incident noticed by involved stakeholders, they outline the sequence of actions and interventions required to get to the root cause of the incident and to resolve it. In particular, the documents show screen-shots of the information displayed on relevant monitoring tools (an example is provided in Figure 3, showing the layout used for the experiment). Additionally, the blueprint documents define the ideal interaction (i.e. elements of explicit and tacit knowledge) path between the involved parties in the experiment. The drill exercise material employed was based and adapted from the “Simulation Exercise Manual 2017” of the World Health Organization [2], to take into account the particularities of skyguide. The WHO standard has the advantage to be an all-round guide that contains many tools and examples. More specifically, the WHO standard proposes a drill exercise that is articulated around the three following phases: pre-exercise, exercise conduct and post-exercise. The exercise was organized and supervised by the Service Design Lab of the University of Applied Sciences Western Switzerland.

A. Pre-exercise

In the preparation phase (January and February 2018), the Service Design Lab organized a Master Class on the 29th of January 2018, where skyguide's exercise management team was introduced to this methodology. The preparation phase started with immersion episodes based on participative observation techniques as well as a series of semi-directed interviews and focus groups. Once we had obtained sufficient insights from the immersion phase, we have modelled different “service processes” experiences using service blueprinting. Consequently, several scenarios have been developed. Finally, three scenarios have been retained involving technical dysfunctions.

B. Exercise conduct

Two two-day workshops have been conducted in the month of March 2018 in Biel in business facilities (Biel is at the intersection of skyguide’s main sites, Geneva and Zurich). In these two workshops, participants have been asked to perform their actual duties in order to respond to given incidents, and to resolve them based on their knowledge of the established response plan and their experience. The purpose of the workshops was to explore risks related to the introduction of new IT infrastructure technologies and service delivery processes through a CIT drill based on the methodology presented in this paper. As the purpose of the exercise is an “ex-ante” (or forward looking) approach, instead of a classical “table top” setting, we have chosen to run a drill exercise to obtain more practical insights regarding the new system that has as a main characteristic to be externalized for part of the process.

Two scenarios related to the new system have been staged (see Figure 3 for the corresponding layout) and rehearsed based on “service blueprinting” techniques in order to include all the different operation roles involved at skyguide’s main sites and supplier’s site located in eastern part of Europe (as well as notions such as the line of visibility, physical evidence and external suppliers). The first day was aiming at familiarizing skyguide with the CIT concept conducted as a drill exercise.

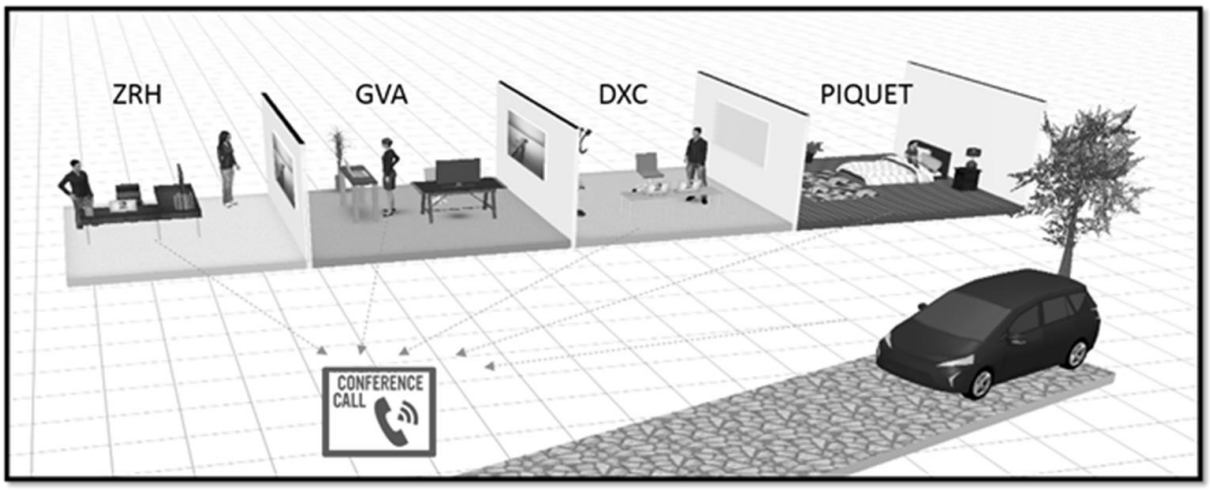

Figure 3. Layout employed to conduct the Critical Incident Technique Drill in Biel, March 2018

The participants have been split into three categories: actors, active observers (different skyguide technical and non-technical profiles) and non-active observers (managers, members of the Swiss Regulator and National Supervisor Authority). During the first day, the team has worked on a first simplified scenario to properly understand the methodology. So as a first step, actors, based on an “inject” (i.e. information revealed to the actors) related to the scenario, had to simulate what could happen after the realization of a given critical incident. The goal of the first simulation was to be “as visible as possible” in order that observers along with actors could conduct a thorough risk assessment associated with the critical incident.
After the simulation, observers and actors were challenged by the drill exercise leader to come up with associated risks. Once done, a given significant risk was selected and the actors had to simulate the scenario by including responses to address the chosen risk (as shown by the model presented in Figure 2).
During the second day, the same logic was applied, except that scenario 2 was more complicated. A third scenario was kept in case some additional time would be available. The actors were then able to simulate the second scenario in a way that all aspects of the critical incidents were visible to the observers. Actors on their own initiative have proposed a risk response based on the inclusion of a “conference call along with remote access dispositions”. The play was very convincing to the point that such “tacit knowledge” can be directly and precisely described in new protocols.

C. Post-exercise

After the exercise, we have analyzed all the information that was collected during the two two-day workshops. All the other risks and responses information generated during the workshops were kept and analyzed afterwards. We have seen that even if we focused on few risks and responses during the workshops, this approach has generated a lot of useful material for the company regarding its digitalization.
In a general manner, all participants have demonstrated a strong team cohesion, commitment to change, skills as well as creativity and rigor. The HES team concluded with confidence after the realization of this exercise that skyguide technical staff has the attitude and skills to adopt the new IT infrastructure service delivery model involving an external partner. Observation templates and participant's feedback template were collected from the simulation exercise in a structured form so that the post-exercise gave birth to a full detailed report used by the management to validate the new process. The main attribute used to assess the theater re-enactment of the blueprints were the following:

1. Timeliness.
2. Clarity
3. Accuracy

4. Pertinence
5. Credibility
6. Accessibility

VI. CONCLUSION

The integration of new digital processes in air traffic control will be more and more recurrent in the future, and as well grounded on more complex business interactions. Consequently, it has to be accompanied by frequent drill training in order to address related risks. The internal communication needs in parallel to be improved because significant change in the organization involving typically new external partner creates concerns among the workforce that must be as well properly addressed. It has been observed during the experiment the CIT drill conducted at skyguide that the team shows cohesion, skills and envy, willingness to change, and determination. Thanks to the CIT drill, we have given the possibility to the team to contribute to innovative processes. The general conclusion that we can draw is that for all companies on the way to digitization, there is a need of change of attitude and mindset. It is thus crucial to train and rehearse these new digital processes regularly before implementing them.

If now we focus on the case of air traffic control, the case of critical incidents related to digital processes, managers are not able anymore to improvise. As processes become "invisible", managers have to be trained to deal with the problem and restore the situation as quickly as possible. Moreover, if the incident lasts some time (several days), transitions between managers that are in charge should also be trained. Today, in most companies those transitions are more or less improvised. It relies too often on good intention of the person in charge of the process (even if this attitude has to be praised). Consequently, the quality of the critical incident resolution should be independent of the persons otherwise things can deteriorate. An interesting point is that the key solution tested during the experiment came directly from the skyguide team. As such, there is an important need to set up drill training and tool to be able to address CI in a more rapid manner and also to include the ever increasing complexity of systems.

The drill exercise at skyguide can thus be considered as a success since risks and opportunities related to the new application have emerged beforehand. Skyguide team has the skill, the mindset, the commitment to address such organizational changes that will become more and more recurrent in the future. However, in order that this approach remains effective skyguide must implement in a regular manner this type of simulation exercises and should also accompany the change with appropriate internal communication.

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